GERB Clear Sky SW ADMs Development: Progress Report

Cédric Bertrand

Royal Meteorological Institute of Belgium,
Brussels, Belgium.
Cedric.Bertrand@oma.be

CERES-TRMM ADMs vs. CERES-TERRA (AQUA) ADMs

- **Several years of CERES-TERRA data**
  - = enough sampling to define ADMs at a higher angular and temporal resolution than CERES-TRMM ADMs
  - = extends the CERES-TRMM data (40ºN to 40º S) by adding mid-latitude and polar observations

BUT: polar Sun-Synchronous orbit designed to cross the equator at the same local time each orbit

⇒ do not provide observations of the angular radiation fields over the full range of θ_0

⇒ empty ADMs angular bins

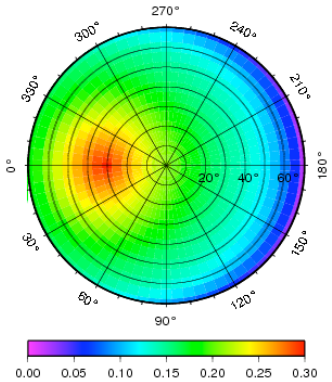
- **TRMM: 350-km circular, precessing orbit with a 35º inclination angle**

⇒ samples each grid box at different local time every day

⇒ full range of θ_0 acquired every 46 days.

GRASSLANDS [5° - 15° N] MONTHLY MEAN SW BRDF
(SZA=30°)

JAN



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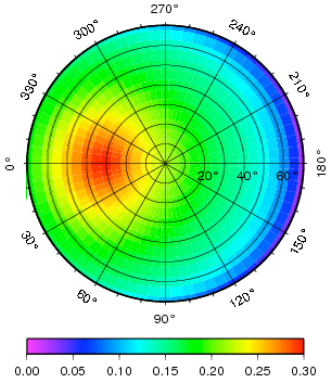

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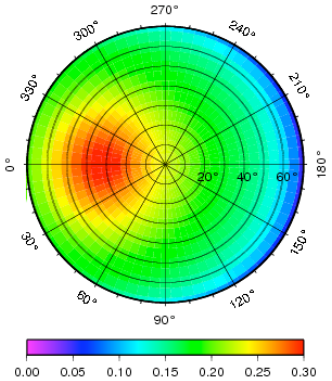

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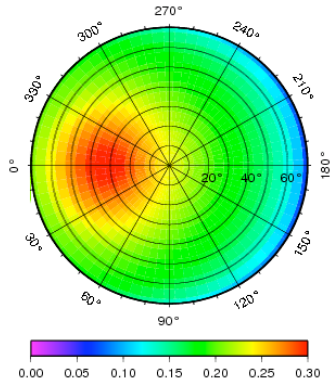

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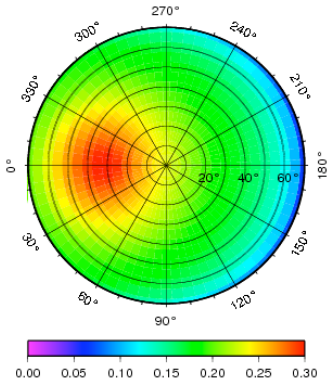

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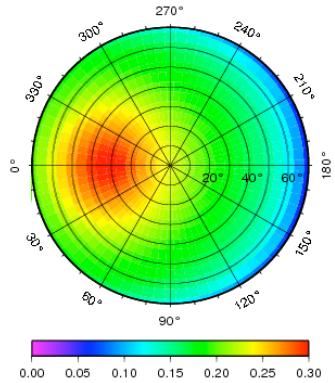

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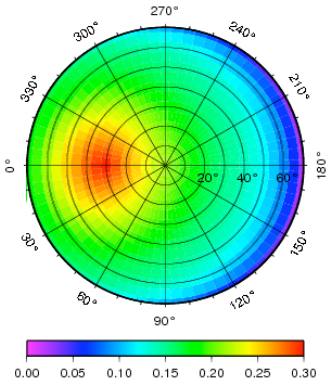

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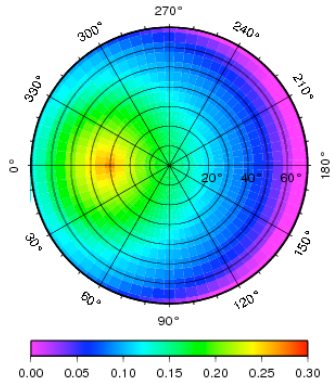

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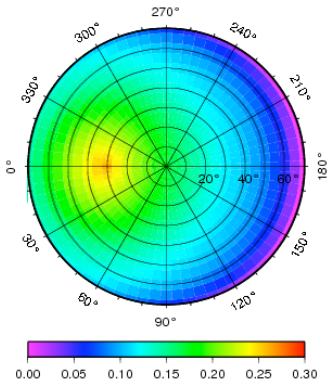

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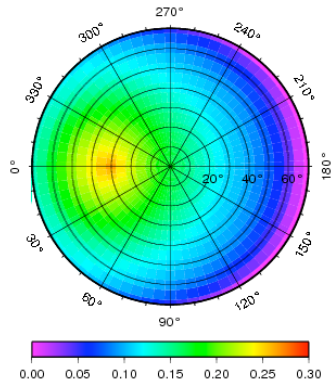

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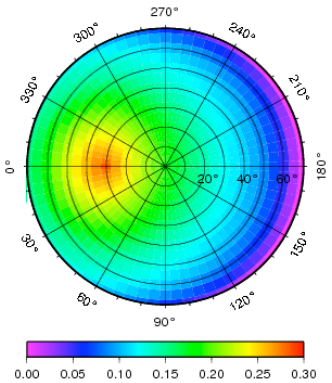

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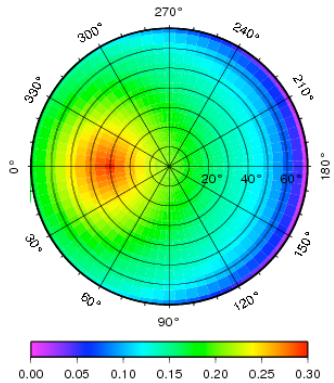
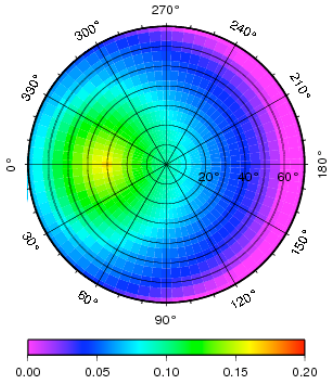


GRASSLANDS [45° - 55° N] MONTHLY MEAN SW BRDF
(SZA=30°)

JAN



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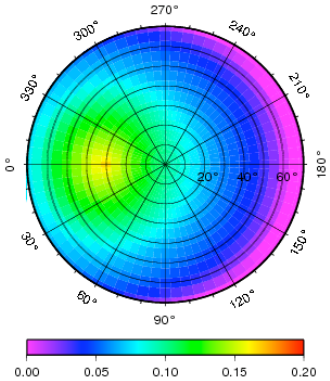

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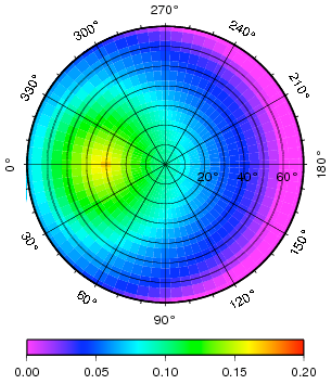

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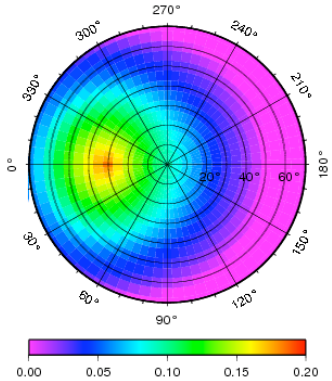

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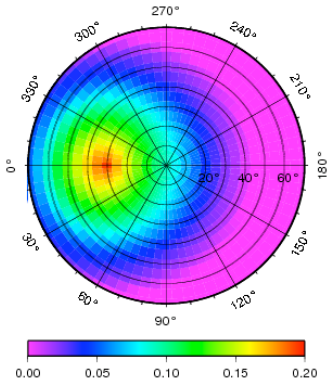

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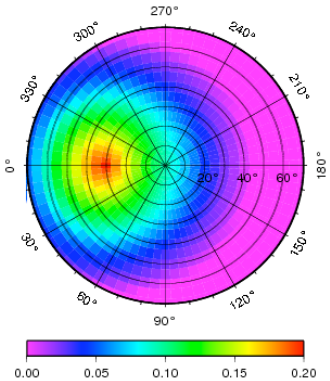

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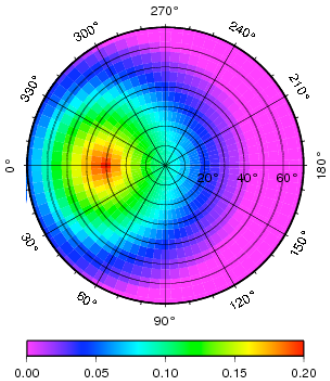

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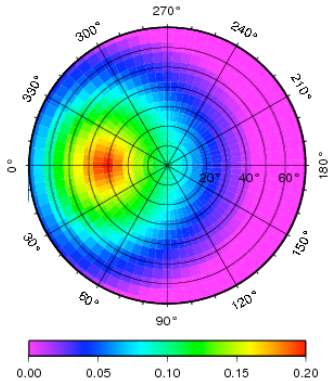

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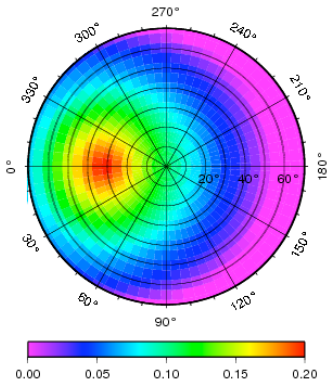

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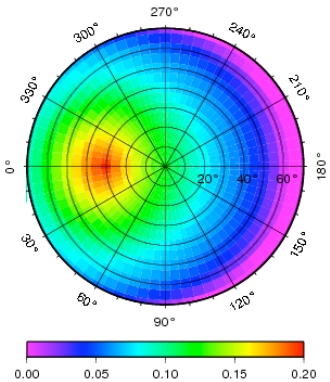

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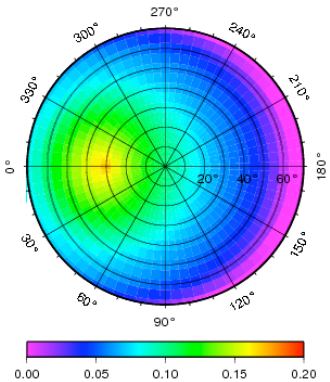

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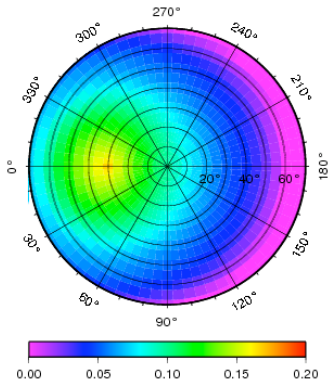
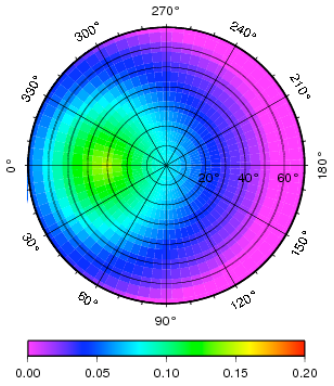


EVERGREEN BROADLEAF FOREST [-5° - 5° N] MONTHLY MEAN SW BRDF (SZA=30°)

JAN



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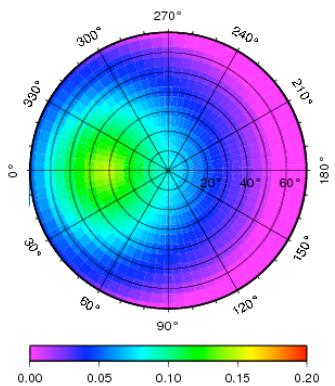

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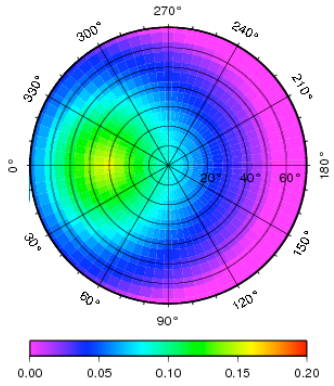

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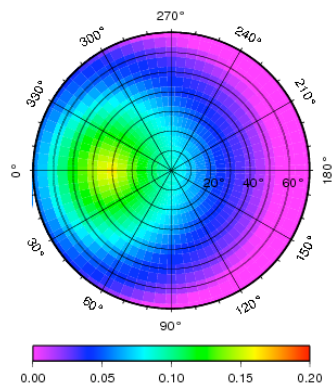

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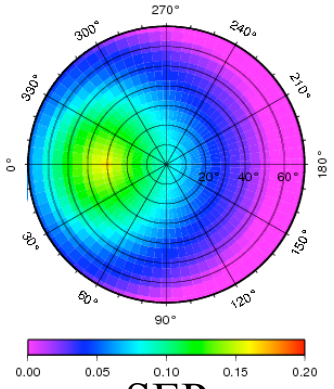

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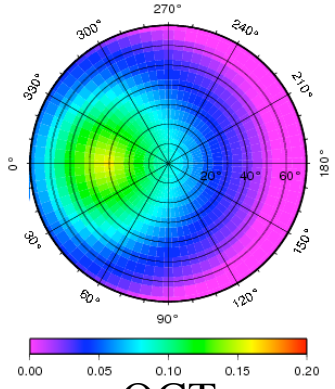

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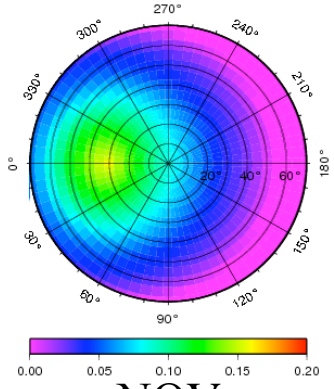

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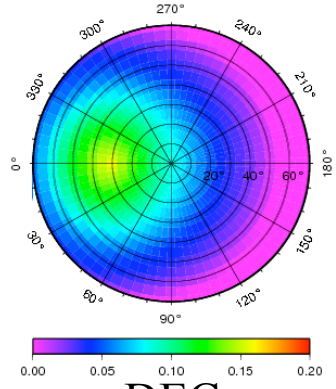

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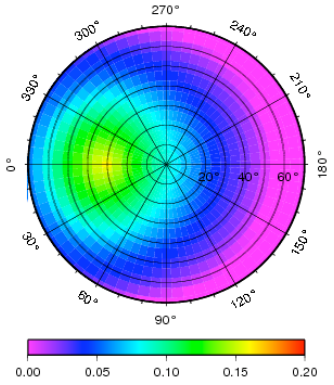

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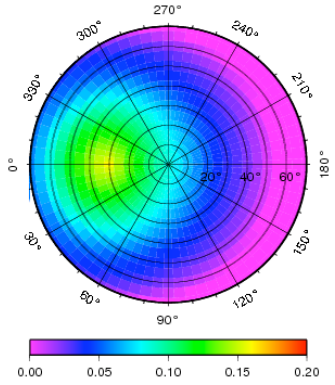
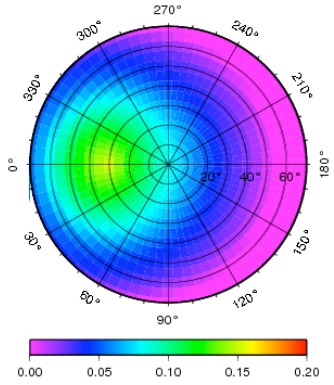


NOV



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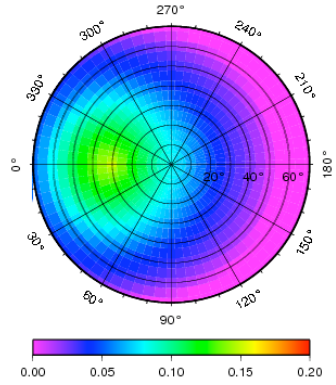


Clear sky land and desert SW Terra ADMs

24 months (March 2000 – February 2002) of CERES Terra Edition 2A SSF data + coincident MODIS measurements

- Defined for 1° latitude x 1° longitude equal area regions
- Temporal resolution of 1 month
- Stratified by 0.1 increment in NDVI (determined from PSF-weighted mean MODIS 0.63- ($I_{0.63}$) and 0.86- μm ($I_{0.86}$) radiances: NDVI = $(I_{0.86} - I_{0.63})/(I_{0.86} + I_{0.63})$
- An 8-parameter fit from Ahmad and Deering is applied to the CERES SW clear sky TOA reflectances to represent the angular dependence in the reflectance field (separate fits are derived for every 0.2 increment in μ_0)
- **TOA albedos** are **computed** by directly **integrating the BRDFs over θ and ϕ** at several θ_0 in the interval of μ_0 in which the BRDF fit was derived. (A fit is next used to represent the albedo dependence on θ_0 in each μ_0 interval.
- Instantaneous **anisotropic factor** at a given location is inferred from the **ratio of reflectance to albedo** (both **evaluated from the BRDF fits** at the FOV viewing geometry)

Clear sky land and desert SW GERB ADMs

9 months of CERES TRMM Edition 2B SSF data + coincident VIRS measurements
6 years of CERES Terra (FM1/FM2) Edition 2B SSF data (03/00 to 12/05) + coincident MODIS measurements
4 years of CERES Aqua (FM3/FM4) Edition 2B SSF data (07/02 to 12/05 – 03/05) + coincident MODIS measurements

$\Rightarrow$ 40°N – 40°S and 20°W – 60°E

VIRS: 0.63-, 1.63-, 3.75-, 10.8-, and 11.9- μm $\Rightarrow$ IGBP type rather than NDVI stratification (75 % surface coverage)

(MODIS: 0.645-, 0.858-, 2.13-, 3.792-, and 11.030- μm)

-Because of requirement on SZA, zonally defined (2° latitudinal band excepted between 16°N and 6°N where a 1° latitudinal resolution is considered)
- (Temporal resolution of 1 month)
- 4 BRDF models are applied to the CERES SW clear sky TOA reflectances to represent the angular dependence in the reflectance field (separate fits are derived for 10° increment in θ_0; i.e. 9 bins in SZA)
  - Roujean model
  - Rahman model
  - RossThickLiSparse Reciprocal model

  } 3-parameter fit

  - Ahmad and Deering Model → 8-parameter fit

Natural Vegetation in Africa

Climate and atmospheric dynamics in the tropics

→ Seasonal regional circulation regimes (= monsoon)

→ strong variations in - surface temperature
- wind fields
- air moisture
- cloud coverage
- rainfall events

North Africa:

wet season = northward shift of the ITCZ
(deep convective activity → intense rainfall → vegetation growth)

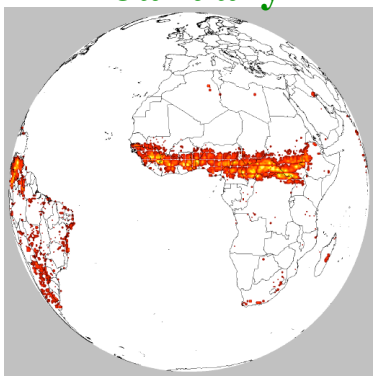
dry season = end of boreal summer
(convective activity → scarce → yellowing and dying off of vegetation)

→ Successive vegetation growth and senescence phase → physiological modifications → changes of spectral signature and brightness of land surface.

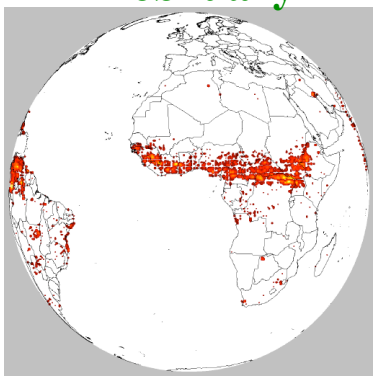
→ Monsoon-Driven Albedo Cycle

1998 Fire patterns Across Africa: VIRS at 0.5° res.

January



February



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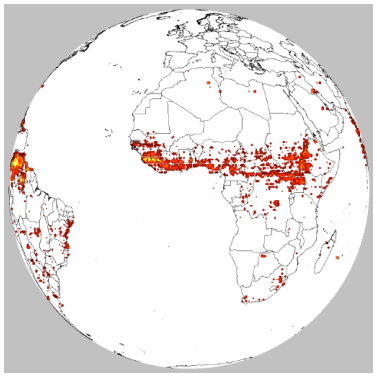

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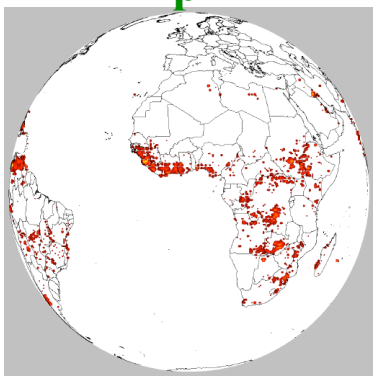

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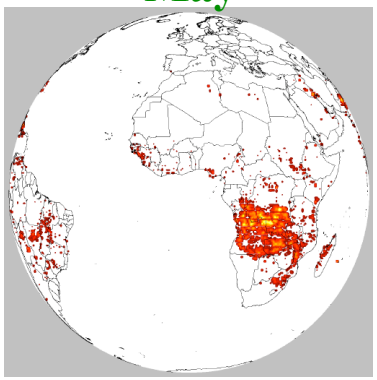

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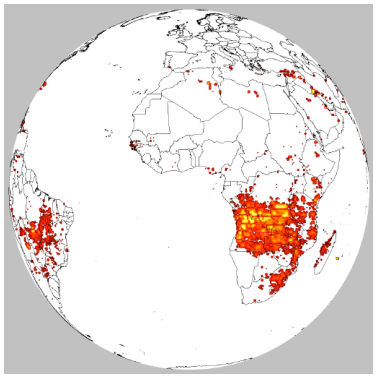
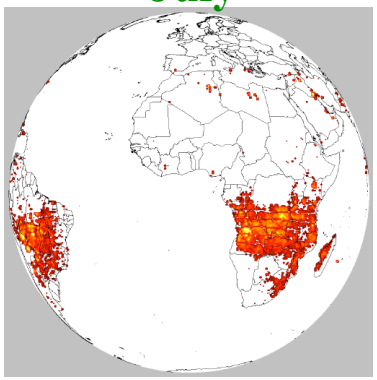
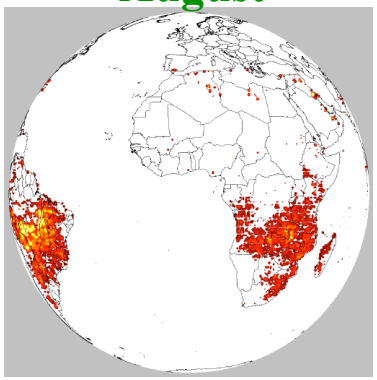


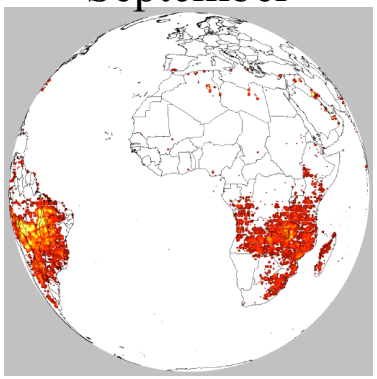
July



August



September



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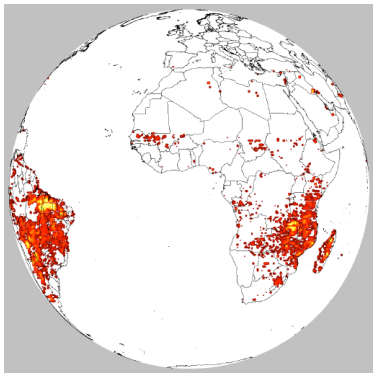
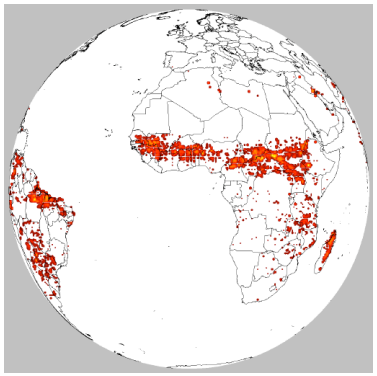
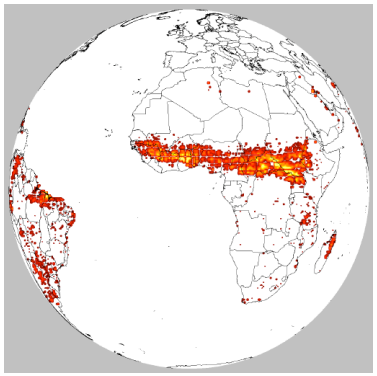


November



December



The burning area shifts from North to South over the course of the year, in step with the coming and going of Africa's rainy and dry seasons

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Clear sky land and desert SW GERB ADMs

Terra ADMs viewing angle sampling criterion to perform a fit:
→ at least 3 CERES FOVs available in the following geometries:
(i) $\theta \leq 20°$
(ii) $\theta \geq 40°$ and $\phi \leq 30°$
(iii) $\theta \geq 40°$ and $60° \leq \phi \leq 120°$
(iv) $\theta \geq 40°$ and $\phi \leq 150°$

⇒ To ensure the stability of the fit: - IGBP surface type fraction coverage ≥ 75 %
- IGBP surface type fraction coverage = 100 %
- Only CERES FOVs available in the above geometries and IGBP surface type fraction coverage ≥ 75 %

⇒ For each fit the albedo is instantaneously computed by directly integrating the BRDFs over θ and ϕ. Only fits for which all the BRDF values have been considered in the albedo computation (BRDF > 0 whatever θ and/or ϕ may be) and albedo value in the range[0, 1] are selectionned.

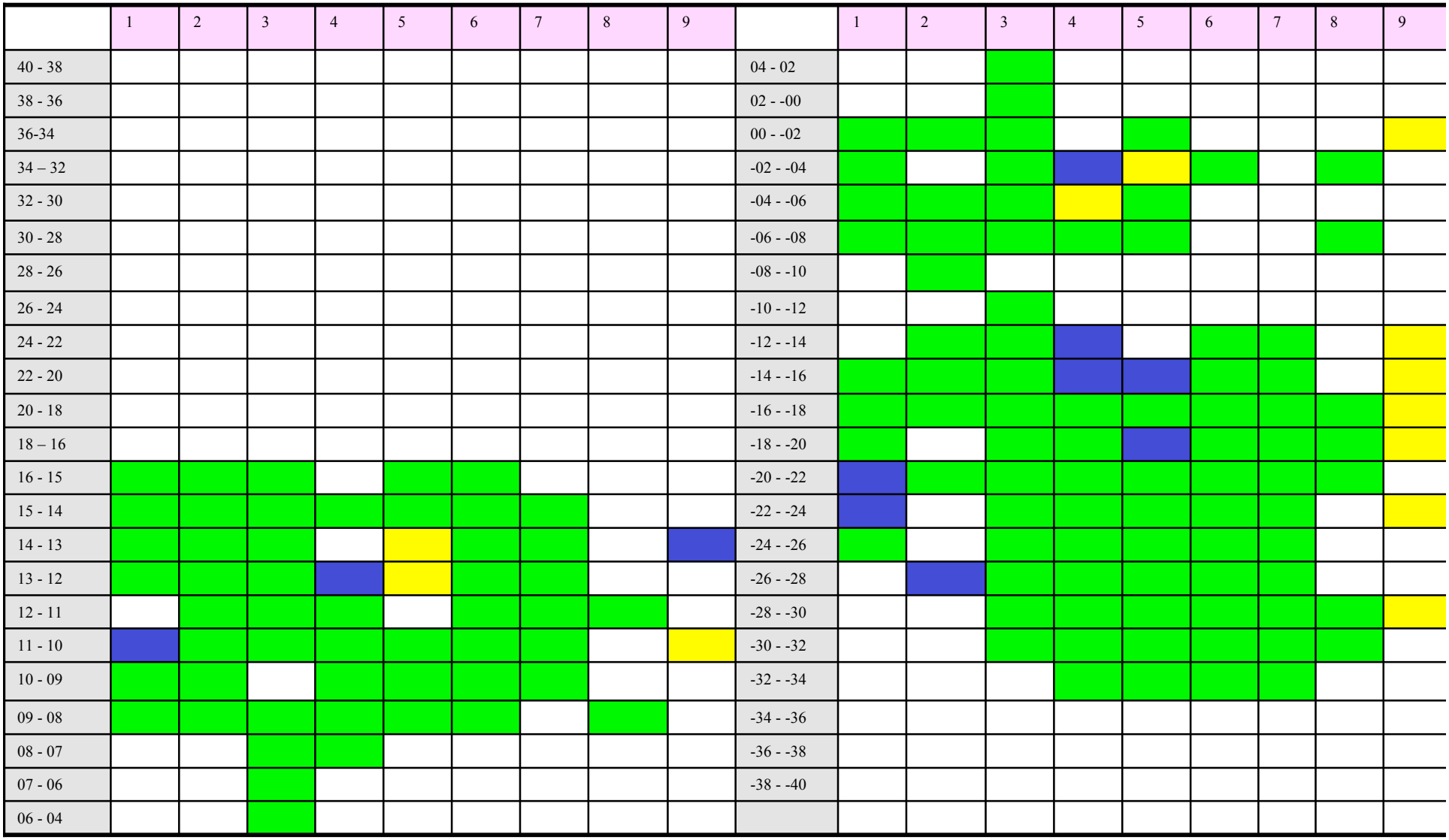
⇒ Because the Roujean and the RossThickLiSparse Reciprocal BRDF models in one hand and the Rahman and the Ahmad and Deering models in the other hand behave very similarly a minimum of 3 models valid inversion is required.

Clear sky land and desert SW GERB ADMs

⇒ For a given IGBP type in a given latitudinal/zonal band the albedo resulting from the direct integration of the BRDF over θ and ϕ in each SZA bins must increase as a function of SZA. In addition only one BRDF model can be used.

IGBP surface type 9: Savannas

Month: March



Rahman model and Ahmad and Deering model

Ahmad and Deering model only

Rahman model only

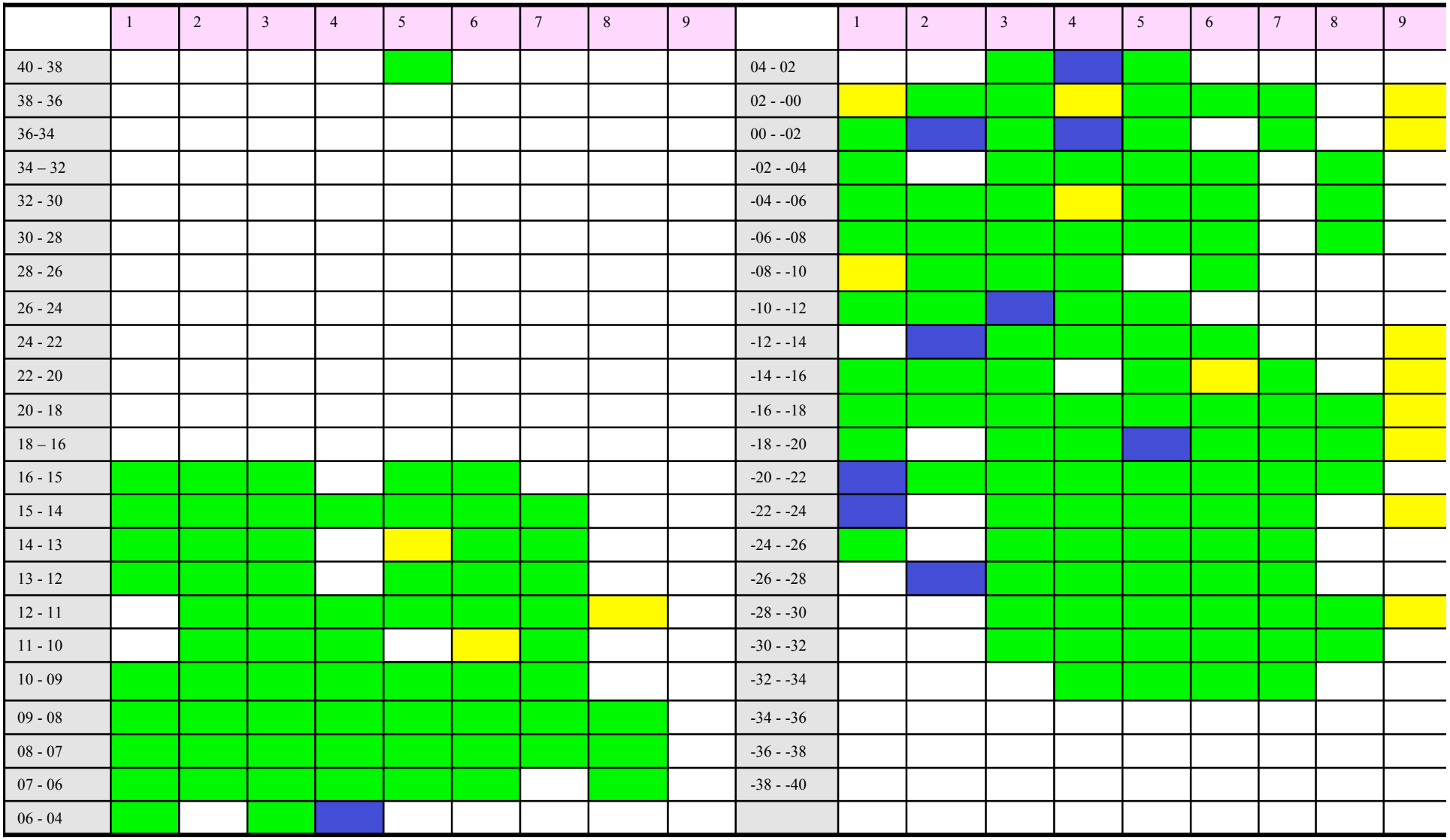
SZA bins: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90

Latitudinal band

Surface-type definitions for clear-sky ADMs over land and desert

CERES-TRMM BB SW ADMs		CERES-Terra clear-sky LW and WN ADMs	
ADM Surface Type	IGBP Type	ADM surface type	IGBP type
Moderate-to-High Tree/Shrub Coverage (Mostly Trees with > 60% Coverage	-Forests (1-5) -Closed Shrubs (6) -Woody Savannas (8)	Forest	-Forest (1–5)
		Savannas	-Woody savannas (8) -Savannas (9)
Low-to-Moderate Tree/Shrub Coverage (Mostly Shrubs with < 60% Coverage)	-Savannas (9) -Grassland (10) -Wetlands (11) -Crops (12) -Urban (13) -Crop/Mosaic (14)	Grasslands/cropland	-Closed shrubland (6) -Grasslands (10) -Permanent wetlands (11) -Croplands (12) -Urban (13) -Crop/Mosaic (14)
Dark Desert	-Open Shrubs (modified 7)	Dark Desert	-Open Shrubs (7) -Tundra (18)
Bright Desert	-Barren Desert (modified 16)	Bright Desert	-Barren Desert (16)

ADM Surface Type: Savannas (woody savannas + savannas) Month: March



Rahman model and Ahmad and Deering model

Ahmad and Deering model only

Rahman model only

SZA bins: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90

Latitudinal band

Clear sky land and desert SW GERB ADMs

⇒Terra ADMs: when a fit can not be derived then CERES FOVs from neighboring regions with the same IGBP type, NDVI and μ_0 intervals are used to supplement the angular sampling. → Only FOVs from neighboring regions within ± 15° latitute x ±15° longitude are considered.

→ If the viewing angle sampling criterion is still not satisfied then a fit is not performed, and fluxes are determined using the CERES TRMM ADMs.

⇒ Limitation: CERES-TRMM data not available for each month of the year !

CERES Terra and Aqua data only

ADM Surface Type: Savannas (woody savannas + savannas) Month: March

	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9
40 - 38										04 - 02									
38 - 36										02 - -00									
36-34										00 - -02									
34 – 32										-02 - -04									
32 - 30										-04 - -06									
30 - 28										-06 - -08									
28 - 26										-08 - -10									
26 - 24										-10 - -12									
24 - 22										-12 - -14									
22 - 20										-14 - -16									
20 - 18										-16 - -18									
18 – 16										-18 - -20									
16 - 15										-20 - -22									
15 - 14										-22 - -24									
14 - 13										-24 - -26									
13 - 12										-26 - -28									
12 - 11										-28 - -30									
11 - 10										-30 - -32									
10 - 09										-32 - -34									
09 - 08										-34 - -36									
08 - 07										-36 - -38									
07 - 06										-38 - -40									
06 - 04																			

Rahman model and Ahmad and Deering model

Ahmad and Deering model only

Rahman model only

SZA bins: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90

Latitudinal band

CERES TRMM data only

ADM Surface Type: Savannas (woody savannas + savannas) Month: March

	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9
40 - 38										04 - 02									
38 - 36										02 - -00									
36-34										00 - -02									
34 – 32										-02 - -04									
32 - 30										-04 - -06									
30 - 28										-06 - -08									
28 - 26										-08 - -10									
26 - 24										-10 - -12									
24 - 22										-12 - -14									
22 - 20										-14 - -16									
20 - 18										-16 - -18									
18 – 16										-18 - -20									
16 - 15										-20 - -22									
15 - 14										-22 - -24									
14 - 13										-24 - -26									
13 - 12										-26 - -28									
12 - 11										-28 - -30									
11 - 10										-30 - -32									
10 - 09										-32 - -34									
09 - 08										-34 - -36									
08 - 07										-36 - -38									
07 - 06										-38 - -40									
06 - 04																			

Rahman model and Ahmad and Deering model

Ahmad and Deering model only

Rahman model only

SZA bins: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90

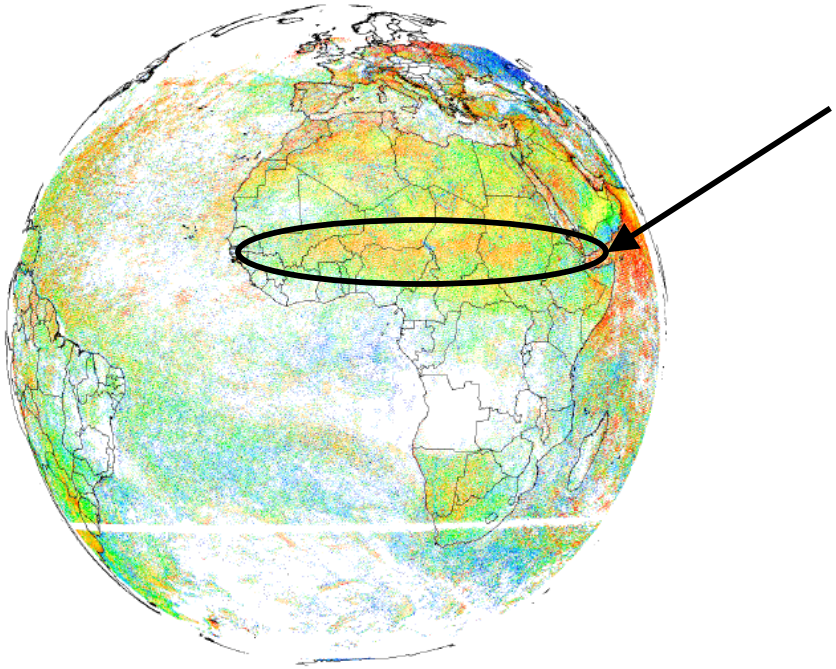
Latitudinal band

December 11-17 2004 Flux Ratio: $\overline{F}_{GERB} / \overline{F}_{CERES}$

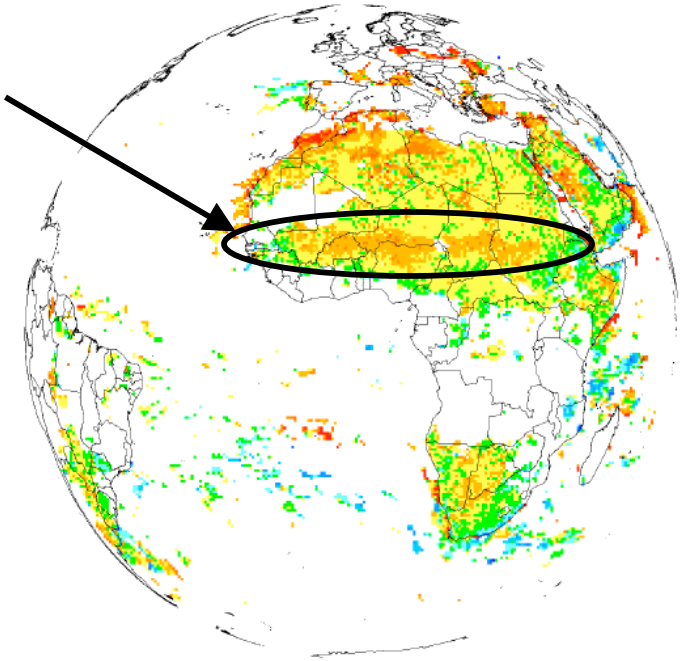
FM1 SSF Edition 2B Revision 1

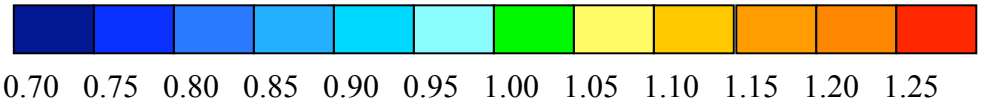
CLEAR SKY

GERB_HR / CERES



GERB_ARG / CERES

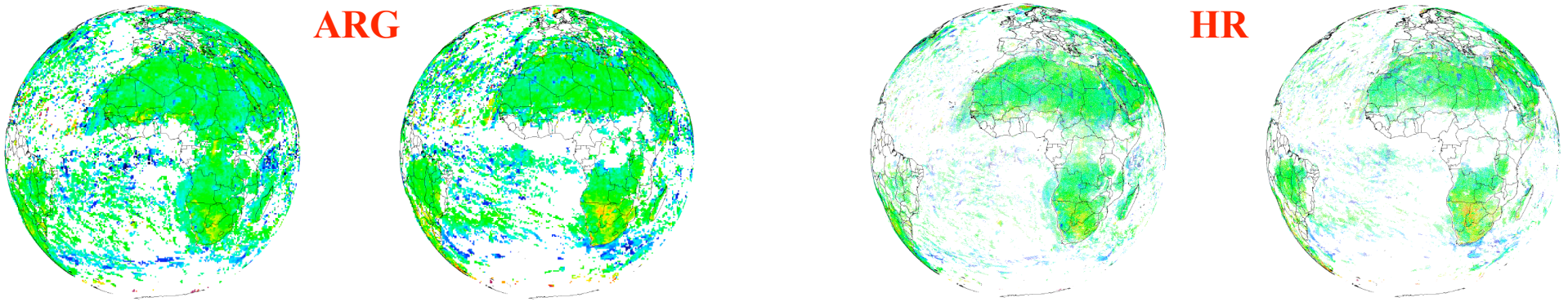




FM1 SSF Edition 2B Revision 1: SSF_TRMM / SSF_TERRA

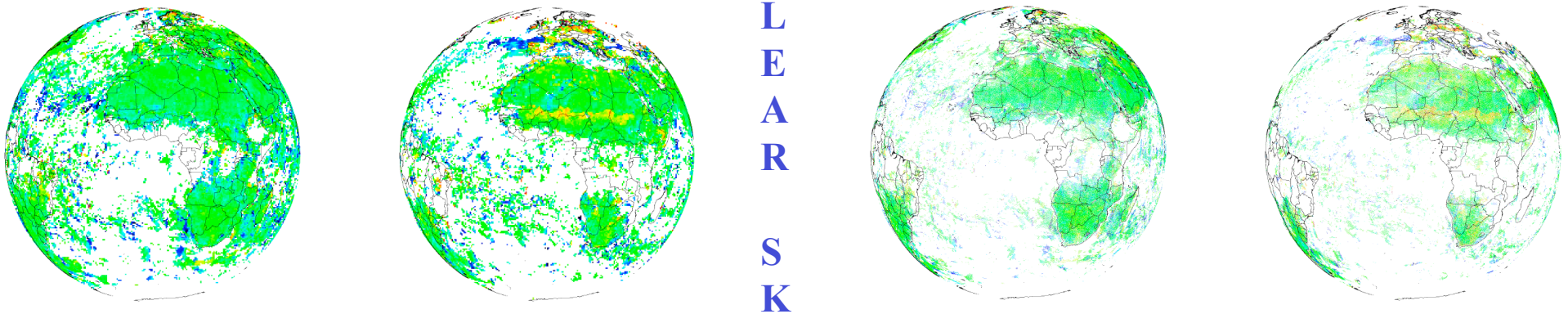
May 01-10, 2004 June 21-27, 2004 May 01-10, 2004 June 21-27, 2004

ARG HR

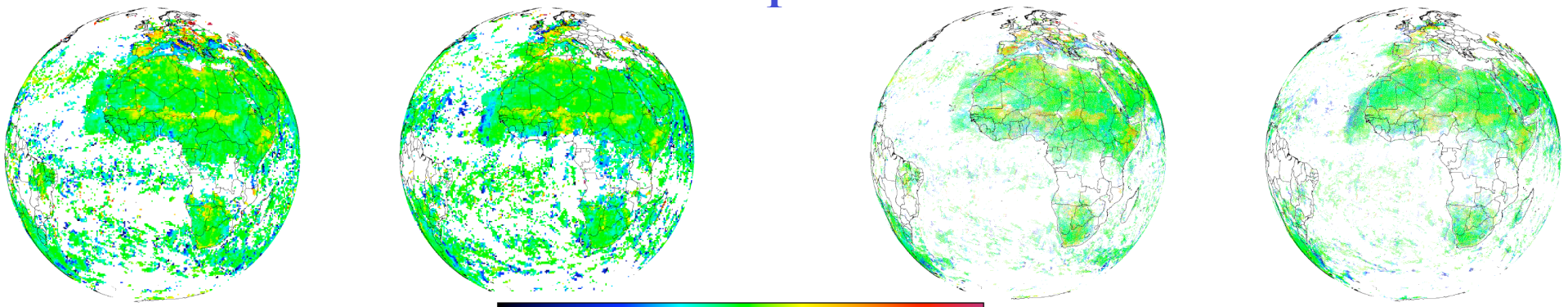


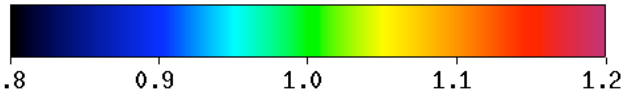
October 01-10, 2004 December 11-17, 2004 October 01-10, 2004 December 11-17, 2004

CLEAR SKY



January 01-10, 2005 February 01-10, 2005 January 01-10, 2005 February 01-10, 2005





TRMM/Terra